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AUTHOR	Egeland, Byron; And Others
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ABSTRACT

Thirty-five second-grade learning disabled children participated in a visual information processing training program designed to teach analysis of visual material into component parts, systematic scanning of visual arrays, pick-up, description, and memory storage of distinctive information, and efficient solution of visual match-to-sample problems. After eight weeks in this experimental program, the treatment group was superior to contrast and control groups on a battery of visual information processing tasks, the Embedded Figures Test, the Matching Familiar Figures Test, and two reading achievement measures. Results from a delayed posttest indicated that the gains were maintained throughout two months of summer vacation. (Author)

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Visual Information Processing: Evaluation of a Training Program for Children with Learning Disabilities[1]

Byron Egeland Robert Wozniak Vicki Schrimpf
Jami Hage Valerie Johnson Amy Lederberg
University of Minnesota

Recent research strongly suggests that there are important developmental trends and individual variations in young children's ability to process information presented to them in a visual display. One of the most important variables of visual information processing is the efficiency with which attention is deployed over the surface of the display. Most of the studies in this area have measured attentional deployment by monitoring eye movements during tasks in which children are asked to scan a visual array for task relevant information (cf., Day, 1975, for a thorough review of this research).

In a variety of tasks, clear developmental changes (Vurpillot, 1968; Zinchenko and Ruzskaya, 1969; Nodine and Lang, 1971) and wide individual differences (Drake, 1970; Siegelman, 1969) in task relevant systematicity and exhaustiveness of visual scanning have been found in children between the ages of four and eight years. Furthermore, these differences appear to be highly related to the child's overall level of accuracy on the visual task. For example, children who are most accurate in making visual match-to-sample judgments have consistently been found to sample more information and to sample information more systematically prior to response than children whose performance in such tasks is relatively less accurate. As might be expected, there is a tendency for children's ability to perform accurately on certain of these visual tasks (most notably the MFF) to be related to proficiency in a number of academic

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areas (Messer, 1970; Kagan, 1965a, 1965b, 1966; Kagan, Pearson and Welch, 1966).

In addition to effective spatial deployment of attention, a child who is to profit from the information in a visual display must be sensitive to the variables of that information. He/She must attend to the relationships among the features of the display which constitute its informational base.

Analysis of the basic structure of such visual information suggests that it is of at least two types. The first type of information has been characterized by Gibson (1969) in terms of "distinctive features,"--properties or patterns of stimulation unique to an object or class of objects in relation to another object or class. Information of this type provides the figurative basis for simple logical classification discussed by Piaget and Inhelder (1958). Differences along many dimensions (e.g., size, contour, internal spatial relations) may constitute distinguishing features; and the child must be sensitive to these dimensions of difference if he/she is to extract the information embedded in a visual display.

A second type of basic visual information is that which is constituted by the relationships which exist between whole objects and their parts--parts which may themselves be whole objects of a lower order. Information of this type, hierarchical structure, provides the figurative basis for infralogical operations (Piaget, 1958). In other words, whereas distinctive features underlie visual discriminations and judgments of similarity and difference, part-whole hierarchical relationships provide figurative support for visual analysis and synthesis. Presumably a child must also be sensitive to the hierarchical structure within which distinctive features are embedded if he/she is to process visual information effectively.

Relatively little research has attempted directly to assess the extent to which there are individual differences in young children's sensitivity to distinctive features or to part-whole hierarchic information. Nonetheless, extensive research by Gibson (1969) and her colleagues on distinctive feature extraction and studies by Elkind, Koegler and Go, 1964; Furth, 1963; Corah and Gospodinott, 1966 on part-whole perception suggests that there are developmental changes in these abilities during the pre-school and early primary years. In addition, work in progress by the current authors (Brandl, Egeland, and Wozniak, 1975; Clarke, Wozniak, and Egeland, 1975) and indirect evidence from the literature on individual differences in analytic-synthetic cognitive style (Kagan, Moss and Sigel, 1963) support the existence of wide individual differences in these abilities in early primary grade children. Most importantly, as with variations in scanning ability, individual differences in sensitivity to distinctive feature and part-whole hierarchical information also appear to be related to school achievement.

On the basis of the information currently available, therefore, it seems reasonable to suppose that some children who do poorly in school, particularly those with intelligence well within the normal range, may do poorly at least in part because they have not yet developed the ability to process visual information encountered in the classroom (in a workbook, on a blackboard, on the printed page) effectively. As part of a long range research project designed to test the implications of this supposition, a detailed program of training and transfer of the three fundamental visual skills, systematic scanning, sensitivity to dimensional differences, and part-whole hierarchical analytic ability, was developed. The study to be reported in this paper was an evaluation of the effectiveness of this program in improving and

maintaining improvement in these skills and in fostering transfer to other visual tasks.

Method

Selection of Subjects: Second-grade teachers from 15 classes in six inner-city Minneapolis Schools were asked to identify children who were having academic problems. Of a total sample of 345 children, 218 were so identified. This sample was screened with Kagan's (1964) Matching Familiar Figures Test (MFF) and four subtests from a Visual Information Processing Test Battery developed within the project (Wozniak, Egeland, Hage, Schrimpf, Lederberg, and Brandl, 1975). On the basis of this screening, 153 children were identified as poor visual information processors. This group was then tested with the Gilmore Oral Reading Test, four additional subtests of the Visual Information Processing Test Battery, the Metropolitan Achievement Test, and the Embedded Figures Test. Based on the results of this additional screening, a final sample of 105 children consisting of those children with the lowest overall level of academic achievement, lowest reading scales, and poorest visual information processing abilities was obtained. These children were randomly assigned to either the treatment group, a contrast group, or an in-class control group.

Measures: Data from the screening administration was used as the present data; the two equivalent forms of the screening measures were developed for post- and delayed posttesting. As indicated above, the evaluation instruments consisted of two standard Visual Processing Measures, the MFF, and the Embedded Figures Test; the Primary Form of the Metropolitan Achievement Test and the Gilmore Oral Reading Test; and eight subtests of a Visual Information Processing Test Battery which was developed within the project. The MFF is a match-to-sample visual discrimination task consisting of a

picture of a common object shown along with six similar variants. Children who respond quickly and make a large number of errors are described as having an impulsive conceptual tempo, while those responding more slowly and making fewer errors are labeled as reflective. The Embedded Figures Test requires a child to locate a simple figure embedded in a complex one. This test is designed to measure a cognitive style dimension initially labeled by Witkin et al., 1962, as field dependence-independence and, more recently, as psychological differentiation or complexity. Complexity is viewed as the extent to which perception of part of a stimulus field is influenced by the entire field, or the ability to overcome embedded contexts in perception.

The eight subtests from the Visual Information Processing Test Battery are as follows: (1) Part-Whole Analysis--assesses the child's understanding of the concepts part and whole. (2) Sentence Repetition--assesses the child's ability to recall hierarchical part-whole relationships presented in a series of sentences. (3) Hierarchical Analysis--assesses the child's ability to analyze a picture by constructing an ordered hierarchy of parts and wholes. (4) Ambigious Configuration--tests the child's ability to visualize an efficient scanning path to organize a configuration of colored pictures. (5) Pair-Description of Geometric Figures--assesses the child's ability to locate and describe features which distinguish members of a pair of geometric figures. (6) Pair-Description of Real Objects--measures a child's verbal recall of distinctive feature differences among real objects. (8) Construction from Memory--assesses the child's ability to recall and reproduce a geometric design. Since the beginning of the project these tests have undergone a number of revisions based on the results of pilot studies and clinical use. In addition, extensive

reliability (Brandl, Egeland, and Wozniak, 1975) and validity data (Clarke, Wozniak, and Egeland, 1975)have been collected. A description of the tests and the instructions for administering, scoring, and interpreting the results are presented in the test manual (Wozniak and Egeland, 1975).

Visual Information Processing Training Program: Following is a brief description of the goals of each of the three units of the training program. Unit I of the program focuses on increasing the child's sensitivity to hierarchical structure of visual displays. The child is taught the concepts "part", "whole" and the nature of the "part-whole" relationship; and is shown how to analyze a whole picture in terms of successive levels of parts and wholes and to synthesize a whole picture from a collection of parts. In addition, the children are shown that something at one level of a hierarchy is a "part" and may at a lower level of the hierarchy be a whole with parts of its own. Similarly, something at one level of a hierarchy is a whole and may at a still higher level be a part of a more inclusive whole.

In Unit II, the child is taught to organize deployment of attention across the surface of the visual display. Both systematicity and exhaustiveness of visual scanning are taught. The child's attention is drawn to the overall configuration of the display and he/she is shown how to use contiguity, and a starting and ending point to plot a path to follow in looking at each aspect of an array. Children are taught to preorganize movement from one object to another (in a picture or around physical space) through identification of the configuration in which the objects are placed, choice of starting and ending point and selection of a path before moving.

In Unit III, the child is exposed to a carefully designed succession of

feature constructs between objects involving a progessively greater number of dimensions of difference. These dimensions of difference include form, size, spatial organization, number, etc. The child is taught how to describe these differences, how to encode them mnemonically using a imagery procedure, and how to employ feature analysis in combination with systematic attentional deployment in hierarchical analysis to solve match-to-sample and recall problems. One of the general theoretical orientations of the program is that children's mastery of "terms" to represent concepts (e.g. part and whole) which they are learning is essential to the further use and generalization of these concepts. Another thread running through every lesson is the importance of the child's learning to describe what it is that he/she is going to do. Even though the visual skills taught in this program are felt to be basic, attempts were made to facilitate the generalization of concepts and strategies learned in the lessons to the broader context of the classroom, home and neighborhood. Detailed instructions and materials are available in Wozniak and Egeland (1975).

Procedure: Six female graduate students, blind as to subject assignment, served as examiners. Six different females, five of whom are certified elementary school teachers, served as program tutors. Children in the treatment group were taught in groups of three for approximately 25 minutes a day, five days/week, for approximately eight weeks. The length of training was allowed to vary in response to the child's progress. However, no child completed the program in fewer than seven or more than ten weeks. Each tutor taught two treatment groups of three children each and two contrast groups of three children each. Children in the contrast group left their classrooms for the same amount of time as the children in the treatment group. The contrast children used curriculum materials in a

variety of tasks such as story telling, coloring, etc., but were not specifically instructed in the visual processing techniques taught the treatment group. The purpose of the contrast group was to control for both the individual attention children receive in the small groups and for exposure to the training materials. Children in the control group remained in the classroom for instruction except for pre-, post-, and delayed posttesting.

The posttest was administered within five school days of the completion of the training program and the delayed posttest was given during the middle of summer vacation, two months after the completion of training and of the regular school year.

Results and Conclusions

Mean error and response time scores for each group on the MFF are presented in Table 1. During the eight-week training period, two children from the training and contrast groups moved. In order to equate the sample size in the three groups, two children chosen at random were dropped from the control group. A three treatment (training, contrast, control) X three time at testing (pre-, post-, and delayed post-) repeated measures yielded a significant treatment ($F = 3.00$, $df = 2/96$, $p < .05$), and time of testing ($F = 6.61$, $df = 2/192$, $p < .01$) main effects as well as a treatment X time of testing interaction ($F = 3.68$, $df = 4/192$, $p < .01$). Simple 1 X 3 ANOVAs were used to look at changes within a group across time and post hoc comparisons were used to evaluate differences between two means within the interaction. The results of these comparisons showed a significant increase in response time for the treatment group with no change for the contrast and control groups. It should be noted that in subsequent analyses simple mean effects and post hoc comparisons were computed even if the interactions were non-significant. These comparisons were justified on the basis of the a priori experimental hypothesis.

Analysis of the MFF error scores yielded a significant time of testing main effect ($F = 35.2$, $df = 2/192$, $p < .001$). However, the main treatment and interaction effects were nonsignificant. These results indicate that although treatment was successful in increasing response latency, there was

no corresponding decrease in errors.

Embedded Figures Test scores yielded a significant time of testing main effect ($F = 46.21$, $df = 2/192$, $p < .001$) and treatment by time of testing interaction ($F = 2.89$, $df = 4/192$, $p < .05$). The between groups main effect was not significant. As can be seen in Table 2, the training group showed a large improvement between the pretest and delayed posttest in ability to overcome a perceptual embedding context. Furthermore, all three groups showed significant gains, even though the increase was greatest for the training group.

Tables 3-8 contain the mean scores for the Visual Information Processing subtests for which significant results were obtained. The Part-Whole Concept subtest consists of a series of four pictures of familiar objects and six questions designed to assess the child's understanding of part-whole analysis. For example, the child is shown a whole picture (e.g., stove) and is asked why it is a whole stove. His/Her response is scored 0-3; 0 for a nonsense response; 1 for a functional response ("because you can cook on it"); 2 for a concrete response ("it has burners"); and 3 for an abstract response ("because it has all its parts").

The mean score on the Part-Whole subtest for each group is presented in Table 3. Significant main effects and interactions were found for the total score. Simple ANOVAs and post hoc comparisons indicated that each of the three groups showed significant improvement across time; however, the training group had higher scores on the post- and delayed posttest than either of the two control groups. These results suggest that children in the training group have a greater understanding of part-whole relationships after training.

Table 4 presents the data from the Hierarchical Analysis subtest. Both the time of testing ($F = 32.81$, $df = 2/192$, $p < .001$) and treatment ($F = 6.81$,

df = 2/96, $p < .01$) main effects were significant and the interaction approached significance ($F = 2.33$, df = 4/192, $p < .06$). As can be seen in Table 4, the performance of the training group showed a large improvement over the course of the program. In addition, group differences on the posttest and delayed posttest showed that the children in the treatment group saw more part-whole hierarchical relationships than did children in either of the other two groups. These results are most encouraging since the concept of hierarchical levels is a difficult one for children at this age and achievement level to understand. Whereas children in the control group would often present relationships between parts and wholes on the same level (e.g., nose, mouth, eyes, and ears, in a picture of a person) rather than at successive levels of the hierarchy; children in the training group were quite successful at noting that the "whole eye is part of the whole face, and the whole face is part of the whole body."

Mean scores on the Ambiguous Configuration subtest are presented in Table 5. On this task the child is shown an array of colored pictures of familiar objects arranged on a page. He/She is then presented with four paths and asked to judge whether each path connects all the pictures on the page. Analysis of the scores from the subtest indicated that treatment by time of testing interaction effect ($F = .61$, df = 4/192, ns) and the treatment main effect ($F = .19$, df = 2/96, ns) were nonsignificant whereas the time of testing across time main effect was significant ($F = 10.41$, df = 2/192, $p < .001$). Comparisons among simple main effects showed that only the training group made significant gains between pre- and posttest. However, for the training group the decrease between the post- and delayed posttest was significant as well. The fact that all three groups showed a decline on the delayed posttest suggests that this form of the test may not have been as equivalent to the pre- and posttest forms as originally thought. For the posttest at

least, training was effective in improving the child's ability to scan a visual array in an organized fashion.

In the Paired Description Geometric subtest the child is shown two designs made up of geometric lines and shapes, five of which are exactly the same on both pictures and five of which vary. Each variation is along one of the dimensions of form, size, number, orientation contour, presence/absence of a line or position. Two scores are derived: the number of differences the child observes, and how specifically the child is able to accurately describe the differences. The specificity and difference scores are presented in Table 6. Analysis of the specificity score yielded significant time of testing ($F = 36.90$, $df = 2, 192$, $p < .001$) and treatment ($F = 10.05$, $df = 2/96$, $p < .001$) main and interaction ($F = 5.87$, $df = 4/192$, $p < .01$) effects. Similar results were obtained for the difference scores of the Paired Description Geometric subtest. For both scores the training group showed significant increases from pre- to post- and delayed posttesting; and the scores at post- and delayed posttesting were significantly greater for the training group than for the two control groups.

The Paired Description Real subtest is identical to the Paired Description Geometric except that pictures of real objects rather than geometric designs are used as stimuli. Results from this subtest are presented in Table 7. Analysis of mean changes for this subtest also showed the training group making significant gains across time and having significantly higher scores on the post-and delayed posttesting than the two control groups. According to the results from both of the Paired Description subtests children in the training group were better able to detect slight differences between two figures and once they had identified these differences they were better able to more accurately describe their location and the dimension on which the variation occurred.

corrected error and comprehension scores of the Gilmore. The failure to find a differential treatment effect on the Gilmore may have been due to practice effect and familiarity with the examiner. Since all children showed large changes over time, it is likely that initial performance on this oral reading test was negatively affected by having to read out loud to a strange examiner. On the post- and delayed posttesting the children were most likely more at ease in this situation and consequently their scores improved drastically.

In summary, children who had received approximately eight weeks of tutoring in small groups performed better on a variety of visual information processing tasks and a reading test than children in either an attentional-materials or a non-treatment control group. On both an immediate posttest and a two month follow-up, the treatment group showed superior performance in their ability to better understand part-whole relationships, see the hierarchical nature of this relationship; and accurately describe this hierarchical relationship. In addition, the ability of trained children to scan a visual array systematically and exhaustively improved as did their ability to recall and reproduce geometric shapes. Improvement was also noted in ability to see small differences between both geometric designs and real pictures and to accurately describe these differences. Results from the Pair Description subtests and clinical observations clearly indicated that the children were better able to identify and focus on relevant distinctive features used to distinguish two similar designs or pictures. Finally, perhaps most noteworthy was the generalization of training effects to MFF latency and Word Analysis and Competency subtests of the group achievement test, since performance on these measures received no direct training during the program.

Table 1

Means for Response Time and Errors on the MFF

Group N = 33	Total Response Time (Seconds)			Total Error Score		
	MFF Form I Pretest	MFF Form II Posttest	MFF Form III Delayed Posttest	MFF Form I Pretest	MFF Form II Posttest	MFF Form III Delayed Posttest
Treatment	99.8	152.4	158.9	12.9	8.6	8.8
Contrast	99.7	105.3	110.8	13.6	9.0	9.6
Control	100.6	101.9	104.5	12.9	10.2	9.1

Table 2

Mean Number Correct on the Children's Embedded Figures Test

Group N = 33	Pre	Post	Delayed Posttest
Treatment	7.6	8.2	13.0
Contrast	9.2	10.1	12.5
Control	9.4	11.0	12.5

Table 3

Mean Scores on the Part-Whole Analysis Subtest of the Visual Information Processing Test Battery

Group N = 33	Pretest	Posttest	Delayed Posttest
Treatment	7.0	11.2	11.7
Contrast	8.3	9.8	10.5
Control	8.0	7.4	10.1

Table 4

Mean Number Correct on the Hierarchical Analysis

Subtests of the Visual Information Processing Test Battery

Group N = 33	Hierarchical Analysis		
	Pretest	Posttest	Delayed Posttest
Treatment	2.3	4.2	3.6
Contrast	2.2	2.9	2.9
Control	1.9	3.1	2.9

Table 5

Mean Scores on the Ambiguous Configuration Subtest of the Visual Information Processing Test Battery

Group N = 33	Pretest	Posttest	Delayed Posttest
Treatment	7.2	8.8	7.6
Contrast	7.3	8.3	7.8
Control	7.3	8.1	7.7

Table 6

Mean Scores on the Paired Description Geometric Subtest of the Visual Information Processing Test Battery; Specific and Difference Scores

Group N = 33	Paired Description Geometric-Specific			Paired Description Geometric Difference		
	Pretest	Posttest	Delayed Posttest	Pretest	Posttest	Delayed Posttest
Treatment	10.7	17.3	16.6	20.7	26.4	24.6
Contrast	9.4	11.8	13.5	19.4	22.1	22.1
Control	11.0	12.2	13.1	19.4	22.2	21.2

Table 7

Mean Scores on the Paired Description Real Subtest of the Visual Information Processing Test Battery: Specific and Difference Scores

Group N = 33	Paired Description Real-Specific			Paired Description Real-Difference		
	Pretest	Posttest	Delayed Posttest	Pretest	Posttest	Delayed Posttest
Treatment	10.4	11.2	13.7	16.3	19.4	21.1
Contrast	9.1	9.7	11.2	15.2	16.9	17.6
Control	10.6	10.8	12.0	13.3	17.9	18.3

Table 8

Mean Number of Errors on the Construction from Memory Subtest of the Visual Information Processing Test Battery

Group (N = 33)	Pretest	Posttest	Delayed Posttest
Treatment	11.4	9.3	10.9
Contrast	11.4	10.0	10.9
Control	11.1	9.6	11.2

Table 9

Mean Scores on the Metropolitan Achievement Test-

Word Association and Reading Comprehension Subtests

Group N = 33	Word Association			Reading Comprehension		
	Pretest	Posttest	Delayed Posttest	Pretest	Posttest	Delayed Posttest
Treatment	20.7	23.5	22.8	6.3	7.9	8.0
Contrast	20.5	23.6	21.4	6.6	8.2	7.3
Control	22.8	23.4	22.8	7.5	8.3	8.1

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